parasitism of the fungus hyphæ on the algæ has not only been shown to be possible but quite probable, and to be the only way to explain the peculiar relations existing between hyphæ and algæ satisfactorily. Schwendenerism, like "The Heterocism of Rusts," may be considered as a settled fact, and our "beloved lichens" must sooner or later be placed among the fungi, where they rightly belong.

The University of Nebraska, Dec., 1888.

AMONG THE ANCIENT GLACIERS OF NORTH WALES.

BY F. JOHNSTON EVANS.

THERE are few spots in the British Isles which present so many attractions to the geological tourist as that most picturesque of localities into which the traveller by rail from Holyhead is suddenly ushered when the "Wild Irishman" express, which had been rushing at the rate of some sixty miles an hour across the Island of Anglesea, after emerging from the Menai tunnel, somewhat abruptly pulls up at Bangor station. Around on every side are piled strange rock formations, tilted and upturned in every conceivable fashion. Within a comparatively short distance are the famous slate quarries of Penrhyn, in themselves a beautiful study; while in nearly an opposite direction are visible the lofty summits of Snowdon and Cader-Idris. Let the reader accompany me in imagination into the midst of this magnificent mountain region, our special object being to wander and speculate, for a brief space, among the ancient glaciers of North Wales. Proceeding through the Vale of Llanberris, we perceive, lying high above the road, near the top of the pass, a huge block of stone which has long attracted the notice of even the least observant traveller. It is perched on the edge of a rock a few hundred feet above the bottom of the valley, on its northern flank—that is to say, on the left hand of the traveller who is ascending the pass. It is from fifteen to twenty feet long, and six or seven feet high, sharp and angular as on the first day that it was detached from the parent mass. It rests on a face of rock which, for a few feet, slopes sharply towards the valley beneath, and then ends in a perpendicular face of rock, and it is so lightly poised on its narrow base, that

a finger-touch would seem sufficient to dislodge it from its precarious position. The thought involuntarily occurs, how came it there? What agency could have transplanted it thither without rounding or breaking off a single corner, and left it where it stands, with so cautious and gentle a hand that it rests securely not at the edge but on the side of a steep and smooth incline? It is utterly impossible that it could have rolled thither; for if so, the momentum which carried it to its present position, must have precipitated it down the cliffs below. In all probability, any force which could have moved it three inches from the top of the incline on which it rests would have been sufficient to send it crashing down to the bottom of the valley. Hardly any traveller can have passed up the vale—from one part of which this rock forms a very conspicuous object—without having had some such thought presented to his mind. Those, however, who are aware that the existence of a great glacier in this valley at some remote period is a geological certainty, will be at no loss to recognize in this rock a remarkable and most characteristic specimen of those transported blocks whose occurrence in various parts of the world, at great distances from the parent formation, was so long a mystery to the philosophic inquirer, but which are now recognized as among the surest indications of glacial action.

Climbing now from the high road to the block I have been describing, we perceive that it is only one—although much the larger—of a great number of similar blocks, which are deposited in the same manner on the sides and at the edges of the sloping or precipitous faces of rock which flank the northern side of the Vale of Llanberris. The greater part of these extend in a well-marked and tolerably regular line, and at elevations varying from 300 to 500 feet above the course of the stream, for perhaps a mile further down the valley—until, in fact, its sides become too steep and precipitous to admit of such deposits being made. Clambering along this side of the valley, we examine the faces of the rock around and beneath these blocks, and find many of them—especially such as have not been exposed to the action of the water-courses which trickle down here and there into the stream below—deeply scored with the characteristic striæ of glacial action. If we now cross to the opposite or southern side of the valley (the flank which lies beneath Snowdon), we shall find all the indications of glacial force—the deep notchings of the striæ, the polished and rounded surfaces which continental geologists term *rochers moutonnés*, and the transported blocks poised

in the most critical manner upon slopes which seem too steep to give them support—still more clearly and unmistakably exhibited.

The transported blocks and glacier scratches in the Vale of Llanberris are so well known to geologists that I simply refer to them to call to the mind of the reader the general aspect of the phenomena which I am about to describe as occurring in other parts of the Snowdon district, where they are not so well known, or so universally ascribed to the action of an extinct system of glaciers. Just at the top of the Vale of Llanberris, there is a hollow in the profile of the ridge which forms its northern boundary. It lies exactly between the cluster of houses called Gorphwysfa on the south, and the lake of Cym-ffynnen, at the base of the two Glyders, on the north. A few hundred yards to the east or southeast of the lowest part, at a distance of not more than 300 yards from the great block of the Vale of Llanberris, there is a little round knoll of rock which rises by itself above the neighboring parts of the ridge. It is something like an inverted basin, so that the ground falls away pretty steeply on either side, and the top is nowhere less than fifteen or twenty feet higher than the surrounding parts. Perched on the very top of this knoll, resting on three points of contact at most, is an irregular piece of rock, of a different formation from that upon which it rests, seven or eight feet long, three or four broad, and as many high. It has never been subjected to any process of abrasion or rounding, for every corner is perfectly sharp and angular—presenting in this respect a marked contrast to the rock on which it rests, which is round and smooth, and somewhat weather-worn. What could have brought this block to its resting-place? To have rolled thither it must have rolled some twenty-five feet up-hill, from whatever direction it had come. The ridge, for some hundreds of yards on either side of the knoll, rises but gently, and presents an undulating surface, along which a sharp oblong, irregular block of stone could by no possibility have preserved for any distance a considerable velocity: and between this knoll and the spur of the Glyder Fawr—the only considerable altitude within a mile of the spot—there is a hollow at least 150 feet in depth. But a little below the top of the knoll, on its eastern slope, is a still more remarkable block. It is about the same size as that which is seated on the summit of the knoll, and similarly sharp and angular, but consists of a coarse conglomerate of a very marked and peculiar kind, in which large round white pebbles, apparently of quartz, are imbedded in a kind of matrix, which looks like a coarse red sandstone. The

most incurious person can hardly fail to be struck with the great difference between the character of this rock and the clay slate upon which it rests. If the observer casts his eye around him, he will be unable to see in any direction traces of a similar geological formation in the neighboring rocks. A few feet further on, however, he will observe a third angular block of stone, larger than the others, but resting, like them, upon two or three points alone. He can hardly fail to be struck with the fact that these three blocks are in as exact and regular a line as if their places had been laid down by the nicest measurement. They run nearly northwest and southeast —about half a point to the west of N. W. and to the east of S. E.— that being the general direction of the ridge which descends from the spur of Glyder Fawr.

If we now remount to the top of the knoll, we shall perceive that the side of the steep inclines towards the hollow referred to before, is dotted here and there with large blocks of stone resting gently upon the sloping rock, or imbedded in the turf. All these, on examination, will turn out to possess the same sharp and angular character ; and all of these suggest the question : Is it possible they could have rolled so far up hill ; and were it possible, could they be as sharp and unrounded as they are? Still, however, we see no sign of the red conglomerate. As we pursue our way northwest towards the spur of the Glyder, we find the ridge growing rapidly steeper, but still we see this regular line of sharp blocks, deposited often on their sharpest edges, and nearly on the edge or backbone of the rock. As we mount, they become larger and more frequent, and amongst the higher rocks are one or two small fragments of red conglomerate—until at length, just behind a huge mass of clay-slate of a size which would do credit to any moraine in Switzerland, we come suddenly upon a block of conglomerate fifteen feet long and ten feet high, large enough and sufficiently overhanging to afford us no mean shelter from a Welsh mountain storm. Five minutes' further climbing in the same direction brings us to a most gratifying sight—a large patch, seventy or eighty yards wide, of the red conglomerate *in situ*—of exactly the same character in every respect as that which we first observed resting on the side of the clay-slate knoll some two miles away. Looking back we shall be able to trace distinctly the line of stones by which we have been guided in our ascent. It is so regular that they might almost have been dropped one after the other by a railway train. On each side of the principal line of stones we may observe other

though less regular lines, by which we may very nearly map out the exact extent of the ancient moraine to which they belonged. The last deposited blocks are not a hundred feet higher than the outcropping of conglomerate; and we are now standing nearly upon the brink of the huge lake of ice which must have filled up the bason of the Glyder Fawr and the Glyder Fach, and poured out through the opening above the well-known little inn of Pen-y-gwryd into the valley of Gwryd, and terminated in the open space of the wide valley. Many of the rocks on the southern side of the opening, just above the lake which now occupies the bottom of the hollow between the two Glyders, present the general appearance of glacier-rounded rocks. But the material is so soft, and therefore so ill adapted for preserving the minuter and more indisputable marks of glacier action, that it would be unsafe to draw conclusions from their configuration, were they not supported by the independent testimony of the old moraine, which, with the exception perhaps of the moraine of the great glacier that filled up the whole basin of Snowdon, is the best defined that we may see in North Wales. The southern side of this hollow—forming the northern flank of the ridge along which lies the moraine of the Glyder—is also of a soft and easily disrupted stone, and much covered with turf and mould; and accordingly we are unable to find any very distinct marks of striæ. The places where the rock is least covered and has been least exposed to the obliterating action of trickling water, are the places where such indications could not be expected to exist—namely, near the top of the ridge, and on its southern flank, high above the Vale of Llanberris.

It is not easy to say to what system the great block in the Vale of Llanberris belongs. An attentive examination will show that it lies higher than the well-defined line of deposits which extend along the same side of the valley. Indeed, it is considerably above the level of the actual crest or col of the pass; and there is no precipitous or disintegrated height in its immediate neighborhood from which it could very well have been detached. Indications appear to be not wanting that the great glacier of the Glyder, at some remote period, rose above the lowest part of the hollow in the ridge toward the Vale of Llanberris, and overlapped the southern flank of the ridge. If so, this block, instead of belonging to the Llanberris glacier proper, is really a contribution from the stones of the Glyder glacier, and was brought down upon its surface from some

of the precipitous heights near the outcropping of the red conglomerate. Of this, however, it is difficult to speak with confidence.

We shall now select a new, and possibly a still more interesting route. At the head of the valley of Nant Francon, towering above Lake Ogwen and the high road from Bangor to Capel Curig, is the sharp and rugged peak called Tryfan—the most precipitous summit and the finest single mountain in North Wales. It is separated by a short, sharp ridge, running nearly north and south from the range of the two Glyders. Tryfan is an irregular continuation of this ridge, terminating abruptly on the Bangor road, and forming the western, as a spur of the Glyder Fach forms the eastern flank, of the romantic and secluded valley known by the name of Cwm Tryfan. The general level of this valley is considerably higher than the road, from which it is little seen, and as the approach to it is over broken and boggy ground, its very existence is unknown to multitudes of those who pass from day to day within a few minutes' walk of the spot. Yet it is one of the most curious in Wales. The explorer, on rounding the shoulder of Tryfan, comes suddenly upon a deep valley of gentle and tolerably regular inclination, half a mile wide and a mile and a half long, full, from one end to the other, of rounded and polished rocks of the most marked and characteristic aspect. They exist, not by the dozen, but by the hundred, and crop out from the moist turf all along the bottom of the hollow and to the height of several hundred feet along its sides. They are found up to nearly the same elevation along both sides of the valley, and above a well-defined line they cease altogether. Sometimes they are mere rounded knolls protruding through the turf and peat, but many of them are broad slabs and walls of living rock, hundreds of feet in length, every corner and angle of which has been carefully and elaborately rounded and polished off. More perfect specimens of the *rochers moutonnés* it would be hardly possible to imagine. Below the level of the glacier boundary, a sharp rock is not to be found, from one end of the valley to the other ; and the vast number of the rounded knolls and shoulders, together with the general coincidence in their forms and in the directions of the polished surfaces, affords conclusive proof that they were subjected to the action of one uniform, regular and constant force. The glacier which filled up this valley must have been, like the glacier of the Aar in Switzerland, remarkable for the evenness of its surface, and for the uniformity of its motion. It must have been almost a *normal* glacier —for there are no sudden contractions of its channel, no anomalous

elevation of its bed. The direction of its flow must have been very nearly uniform, from its origin just beneath the ridge which connects Tryfan with Glyder Fach to its termination in the broad valley which the Capel Curig road pursues. Such a confirmation is unfavorable alike to the development of a large moraine and to the existence of that excess of pressure against the sides and bottom of the glacier which causes the deepest striations of the polished surface : and hence these indications cannot be expected to be found of so striking and unmistakable a character as in the "Cwy Dyll," the great hollow of Snowdon, with its irregular bed and contracted orifice, or in the narrow outlet of the gorge of Aberglaslyn. Nor is the rock of a kind favorable to the preservation of the minuter traces of glacier action. Still, some may be seen of a peculiarly interesting and instructive nature. The extreme regularity of the bed of the glacier, the unusual absence of all disturbing or anomalous conditions, has given rise to the formations of striæ of great length and regularity. Some of those which score the rounded rocks on the southern flank of the valley are as much as fifteen or twenty feet long, and very distinctly marked. They are the more interesting as they intersect the line of stratification, and are crossed at right angles by the superficial markings caused by the dropping of water. From the upper end of the valley the view is very striking. If we stand by the shore of the ancient sea of ice which has now melted from the sight, we can define with precision the limits which bounded it on every side, and look down upon a succession of worn and rounded surfaces, which though upon a smaller scale, are hardly less curious or characteristic than the old glacier bed of the Höllenplatte, which is crossed by the traveller from Meyringen to the Grimsel.

While one considerable glacier thus poured from the eastern base of Tryfan, one of immensely greater extent—so long, indeed, that it would bear comparison with some of the existing glaciers of Switzerland—streamed down to the northwest, occupying for many miles the valley of Nant Francon. This glacier had its origin in the romantic amphitheatre of rocks and precipices which surround Lake Idwal, one part of which is well known as the "Twll Du," or "Devil's Kitchen," and extended for at least five miles down the valley towards the spot on which Bangor now stands. The rounded and striated rocks which still tell the history of this glacier are to be found in considerable abundance, and of very characteristic form and aspects, all along the Vale of Nant Francon. No better speci-

men of a *rocher moutonné* exists in Switzerland than is to be seen on our left hand, as we are descending the valley, at the bridge just below Lake Ogwen, and within a few feet of the road. On the other side, the rocks rise precipitously above the road, and the glacier must have been borne with great force against the wall of rock which there checked its progress and altered its direction. Although the rock is not of a very durable kind, it is conspicuously rounded to a height of some 250 feet, where the limits of the glacier level are apparent. The upper rocks overhang the lower, and are very rough and jagged, with a trace of rubbing. Below the road on the left hand, terrace after terrace of rock is rounded and smoothed. This is the part of the valley where the glacier traces are most prominent and striking. Here, they actually obtrude themselves upon the eye, but they do not cease for many miles. The gently descending line of the glacier level may be easily traced from the road along the opposite side of the valley, the smoothing action being the more apparent from the contortion of some of the strata, as seen in the upper and unworn faces of the rock. Between five and six miles from Bangor is a very interesting group of rocks which crop out from the turf in a little wood above the road. They formed somewhat of an elevation in the glacier bed, and have consequently been subjected to severe pressure. They are worn very round and polished quite smooth, and the striæ are most distinct, passing sometimes up-hill, over the undulating surfaces.

The most striking evidences of glacier action, however, are to be found in the great hollow of Snowdon, which is literally full of them. From some distance above the Copper Lake, almost to the bottom of Nant Gwynant, they stare at us in the face at every step. The "Cwm Dyll" was one vast mass of ice from whose bosom the peak of Snowdon rose to the height of some 1000 or 1200 feet at most. Grib Goch, Grib-y-ddysgyl, Snowdon, and Lliwedd formed an amphitheatre of mountain peaks enclosing the great Snowdon glacier, as the chain of the Aiguille Verte and the de l'Echand guard the Jardin and the glacier du Talèfre; names doubtless more familiar to American travellers than those of the subsidiary peaks in the Welsh mountain ranges. A large proportion of the rock in the basin of the Snowdon range is very hard and smooth, and has preserved, in singular freshness, even the minutest scratches. It is curious to trace, as we descend from the summit of Snowdon into the bosom of the hollow, the gradually diminishing inclination of the glacier and its increasing pressure, as marked by the dimin-

ishing slope and deeper *intaglio* of the striæ. The moraine also of this glacier is wonderfully perfect. The cart-road from the now abandoned copper works is cut partly through the lateral and terminal moraines; and the sections might, save for the different geological character and the smaller size of the blocks, be that of the ancient moraine of the Mer de Glace between Les Tines and Lavanchi in the valley of Chamouni. There is the same utter absence of sorting in the disposition of the materials, and the same angularity in individual blocks—the whole being cemented together by a fine deposit of grit and sand. To use the words of Professor Forbes, in his description of the Chamouni moraine: "We find the mound to be almost entirely composed of detached fragments, rough and angular, or only rounded by partial friction, and accumulated in the utmost disorder, mingled with sand, without any appearance of stratification." Among the fragments of stone exposed by the cutting are some very interesting ones. They have originally belonged to the bed, or to the containing wall of the glacier, much higher up, from which they have been detached after being highly polished and deeply striated; and being now uncovered, they display the notchings and scourings, not, of course, in their proper and original directions, but just as they happened to have fallen when the stones were deposited in the places they now occupy.

It must have been a strange scene of desolate magnificence that North Wales presented at the epoch I am writing of. There were Snowdon and his associated peaks, the centres of one vast system of glaciers, pouring down on every side, east, west, north, and south—the Vale of Llanberris choked with ice, and fed from the heights and recesses on either side—a great glacier, taking its origin in the deep basin between Snowdon and Lliwedd, streaming up the valley of Nant Gwynant, diverted a mile or two above the site of the sleepy little hamlet of Beddgelert, by the opposing rocks at the lower extremity of Llyn y-Ddinas, and at length struggling through the narrow gorge of Aberglaslyn, rounding and scoring its rugged sides to the height of hundreds of feet. Another great glacier probably descended through the deep inlet which reached from below Llanberris to the very heart of Snowdon, extending to within four or five miles of the present coast line, and leaving records of its passage which to this day are apparent on every uncovered surface of rock along the Llanberris and Carnarvon road. Nor did the Snowdon glaciers, though the greatest, constitute the only glacier

system in Wales. It is certain that from the group of the Glyders and Tryfan, no less than three glaciers—one of vast extent—poured into the vales and plains below; and probably round every peak or group of nearly equal height, and whose masses are broken up into those deep hollows and amphitheatres which are so favorable to the collection of a reservoir of snow—and, in a climate of variable temperature, to the consequent development of glaciers—similar ice-streams must have filled up the valleys and choked the gorges in every direction. The great peculiarity of this scenery must have been the small elevation of the peaks and mountain ranges above the general level of the glaciers. In Switzerland the summits commonly tower for thousands of feet above the highest parts of the highest glaciers, properly so-called; and the great glacier basins and reservoirs are commonly bounded by huge aretes of bare and rugged rock, specked only with snowy deposits, such as the ranges which hem in the glaciers de l'Echand, the central tributary of the Mer de Glace, or which block up the extremities of the glacier of the Aar and the lower glacier of Grindelwald. In Wales, the corresponding heights must have been measured by hundreds, instead of thousands of feet, for many of the glacier basins themselves lie high; and in this respect, despite the magnificent effect of such a wide expanse of snow and of broken and crevassed ice, the difference must have been unfavorable to the grandeur of the scenery. Something of the same kind may be seen in the northern glaciers of Norway, though the heights which surmount them are higher above the glacier level than was probably the case in North Wales, and there is no reason to suspect the existence in Wales of those vast fields of snow whose aspect and distinguishing peculiarities are so essentially different from those glaciers, and which give to the scenery of Norway a character so unique and extraordinary.

THE FOOD OF THE OWLS.

BY W. S. STRODE, M.D.

A FEW years ago Pennsylvania, Ohio, and some of the more eastern States enacted laws offering a bounty of fifty cents per head for all hawks and owls that should be killed.

This munificent bounty aroused the professional hunters, and for the time being legitimate game was abandoned in many sections of